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IMPOUNDED WATERS OF ALABAMA IN RELATION TO PUBLIC HEALTH

By Edgar B. Kay

The streams of Alabama for nearly a century have been utilized for navigation, public water supply and as sources of power in the operation of cotton mills, saw mills, grist mills, gins, and other manufacturing plants. In these operations numerous dams have been constructed, the flow of the streams for a time impounded, partially controlled and regulated for the manufacturers and users.

Within the last few years the plan of canalizing the larger streams in order to give the inland cities, iron and coal interests as well as the diversified agricultural and manufacturing industries, the advantages of water transportation, has resulted in the construction of many large dams and impounding basins extending for hundreds of miles along the Alabama water courses.

The development of long distance electrical transmission of power has made available the hitherto inaccessible and remote potentiality of streams, which are being harnessed for the service of man and use in the upbuilding of the Commonwealth. The impounded waters resulting from the construction of dams and structures employed in the operation of these hydroelectric plants are important links in the canalization projects of the government to aid navigation. In addition these dams serve the important work of flood prevention by assisting in the regulation of the discharge of streams.

Out of the recent improvement and utilization projects in Alabama, there has developed a great deal of litigation. This litigation has been inspired, almost entirely, by unscrupulous lawyers and land sharks, who have systematically canvassed the territory contiguous to these hydraulic works and have made the credulous country people believe that they could secure large sums from the corporations developing these hydroelectric plants. Many of these people who are the perennial victims of chronic malaria and hookworm anemia, have been led to believe that their latest troubles are entirely due to the formation of a large body of slowly moving

water in the vicinity, which body of water is nothing other than an enlarged section of the original river due to decreased velocity.

The largest power company in the state is at present defendant in some 700 suits, aggregating approximately $3,000,000 damages claimed, these suits being filed in the four counties through which the lake extends, caused by the dam at Lock No. 12 on the Coosa River.

It is the purpose of this paper to briefly outline the character of the impounded waters in Alabama, in their relation to public health and to call attention to the necessity of having carefully made preliminary topographic, geologic and sanitary surveys in connection with similar future projects.

DRAINAGE BASINS

The five principal drainage basins of the state are:

First, The Apalachicola Basin, draining to the Chattahoochee and Apalachicola Rivers, and entering the gulf at Apalachicola, Florida.

Second, The Choctawhatchee Basin, draining to the gulf through Choctawhatchee Bay.

Third, The Pensacola Basin, draining to Pensacola Bay and Perdido Bay, near Pensacola, Florida.

Fourth, The Mobile Basin, including the waters of Tallapoosa, Coosa, Cahaba, Alabama, Warrior and Tombigbee Rivers and draining into the gulf at Mobile, Alabama.

Fifth, The Tennessee Basin, draining into the Tennessee River and thence through the Mississippi to the gulf at New Orleans.

The water powers of the state are mainly in the Mobile and Tennessee basins, which practically cover the entire state, except a small area in the southeast corner.

From Westpoint, Georgia, southwards, the state line of Alabama is on the west bank of the Chattahoochee River where ordinary vegetation ceases to grow. This leaves all of the water power of the main stream on Georgia territory.

The Alabama Geological Survey, in coöperation with the United States Geological Survey, has for a number of years been engaged in a systematic investigation of the water resources of the state.

The annual average precipitation in the northern district of the state is 51.23 inches, and in the southern district 51.47 inches. There have been wide variations from the annual average precipi-

tation. In 1900 the average for the year was 66.73 inches and in 1904, the year of minimum rainfall and run-off, 39.58 inches.

While the proportion of the rainfall which appears in the run-off of the streams varies between very wide limits, depending upon the geological formations, the locality, etc., in Alabama, on an average, about 50 per cent of the rainfall is lost through evaporation, and the remainder forms the run-off of the streams; and curiously enough, only a small percentage of this run-off is supplied by the surface water alone, for most of it reaches the water courses by underground seepage.

In the course of this underground circulation the water reaches the surface from springs, many of which are very large, such as those at Tuscumbia, Huntsville, and Jacksonville, which are the sources of the municipal water supply, from ordinary shallow and deep wells, and from artesian wells.

The main channels in this run-off system are navigable all the year for boats of light draft, except the Tallapoosa and Coosa Rivers, and the canalization of the Tombigbee and Warrior Rivers, by the construction of seventeen dams and locks, has established water transportation from the Birmingham district to the gulf. A fleet of self-propelled barges of 1000 tons capacity each is now making regular trips between Tuscaloosa, Alabama, and New Orleans. Iron is also moving from Holt, north of Tuscaloosa, to the gulf by the water route.

It may be said in a general way that the streams have their greatest fall in passing from an older to a younger geological formation. Tallassee Falls, on the Tallapoosa, and Wetumpka Falls, on the Coosa, are made in passing from the Crystalline to the Cretaceous. Those on Talladega Creek and other small streams in entering the Coosa Valley from the southeast in Talladega, Calhoun, and Chelburne Counties, are from the Crystalline to the Paleozoic. The shoals above Centerville, on the Cahaba, above Tuscaloosa, on the Black Warrior, and near Tuscumbia, on the Tennessee River, are made in passing from the Paleozoic to the Cretaceous. As the Coosa River runs off of the Paleozoic onto the Crystalline near Talladega Springs, the shoals above this point reverse the general order by being made in passing from a younger to an older formation.

The Crystalline area in Alabama is a plateau ranging from 500 to 2000 feet above sea level, of triangular shape on the east side of the state. The rivers flow over bed-rock in a succession of shoals and

eddies between high hills, and present conditions most favorable to the development of water powers with high head. On the Tallapoosa River at Tallassee Falls, a head of 64 feet has been partially utilized for a number of years in the operation of cotton mills, and also a 40-foot dam about three miles above Tallassee is utilized for the generation of electric current which is transmitted to Montgomery. At Cherokee Bluffs, about 15 miles above Tallassee, a dam 125 feet to 150 feet in height is contemplated by the Alabama Power Company.

The falls on Coosa River, from Marble Valley to Wetumpka, are 235 feet in 45 miles. During the past year a dam 60 feet in height has been completed at Lock 12 on this river, the hydroelectric power developed at this site being transmitted to the Birmingham district.

The Paleozoic area includes the greater portion of northern Alabama, being bounded on the southeast by the Crystalline area, and on the southwest by the Cretaceous and later formations of the Coastal Plain. The Paleozoic area is somewhat higher than the Coastal Plain, and slightly lower than the Crystalline area. Its rivers have considerable fall. There are many important creeks and many large limestone springs in this region. The area is rich in coal and iron, the most productive mines being in the drainage basins of the Cahaba and Black Warrior Rivers, the Cahaba River has a fall of 121 feet in 21 miles. The Black Warrior River above Tuscaloosa has a fall of 100 feet in 30 miles. The Tennessee River above Waterloo has a fall of 155 feet in 41 miles, 85 feet of which is in a distance of only 14 miles.

The Coastal Plain is a large area in southern and western Alabama, covering about two-thirds of the state, and is underlain by Cretaceous and younger formations. In the upper portion of this area the streams are not sluggish. There are many streams that have a constant water supply and sufficient fall for the development of good water powers. One of these is the Pea River, the main tributary of the Choctawhatchee River, on which a dam giving an effective head of 31.4 feet has been constructed and the power developed is being transmitted electrically to Troy, Alabama, 32 miles distant.

Birmingham's principal source of water supply is derived from the Cahaba River, on a branch of which—the Little Cahaba—a large impounding reservoir has been built.

The dams on the Warrior are utilized at present only for naviga-

tion, although efforts are being made to utilize the power at Lock 17 in connection with large impounding reservoirs to be built on the Mulberry Fork of that river.

Only a beginning has been made in the development of the great water power resources of the Alabama rivers. The largest available powers remain undeveloped. Of the nine plants now in commission, the Dadeville, Sylacauga, and Goodwater plants are municipally owned; the other hydroelectric plants are the state convict department's plant at Speigner, the Etowah Light and Power Company, near Gadsden; the plant at Lock No. 12 on the Coosa River owned by the Alabama Power Company; the Montgomery Light and Power Company, above Tallassee Falls; the Pea River Power Company, at Elba; and the Centerville Light Company, near Centerville.

While only a beginning has been made in the development of hydroelectric powers in this state, numerous power sites have been utilized ever since the state was settled, for manufacturing purposes, such as the operation of cotton mills, cotton gins, grist mills, saw mills, etc. In the Geological Survey of Alabama Reports will be found a list of 987 utilized powers on Alabama streams.

It is therefore seen that this state is abundantly supplied with large water courses, with many beautiful tributaries having branches reaching every part of the commonwealth; and that numerous impounding basins have been constructed during the past century, mostly for manufacturing purposes, while more recently large dams have been built either to aid navigation or in connection with hydroelectric developments.

IMPOUNDED WATER IN RELATION TO PUBLIC HEALTH

The waters referred to in this paper are those caused to be temporarily stored by dams on Alabama streams, in which running water will always be found and by reason of which fact there is practically always a forward or downstream movement of the water impounded.

In the case of the pool above Lock No. 12 dam on the Coosa River—the back waters of which extend upstream about 30 miles—there is a complete renewal of the impounded water every five days during normal stages of the river.

Whether the effect of a dam constructed in any locality is to lessen or increase the healthfulness of the community contiguous to the

lake or pond created by the dam, is a question which can only be determined by careful topographical and biological surveys of the site and neighborhood before and after its construction. It is first necessary to ascertain the change in physical conditions before any conclusion can be arrived at. The primary purpose of the survey is to determine:

1. The influence impounded waters exert on the health of the surrounding community.

2. The conditions which affect this influence favorably or otherwise for good or for ill.

3. The measures to be taken to minimize deleterious effects and to increase to a maximum the beneficial effects.

The importance of the problem can be readily understood since it concerns the impounded waters of many of the large power and manufacturing plants now utilizing water power.

While nearly all of the litigation at present in the Alabama courts relating to the influence of impounded waters is in connection with the incidence of malaria, there have been many cases involving the pollution of water in ponds and of streams by emptying into them sewage, manufacturing wastes and mine waters.

In the *Southern Reporter*, volume 60, will be found the Alabama Supreme Court decision, January 16, 1913, in the case of W. H. Hosmer vs. Republic Iron and Steel Company.

Several years ago the Republic Iron and Steel Company built a small dam across one of the tributaries of the Warrior River, at a place called Greeley, in the northern part of Tuscaloosa County, to impound water for use at its ore mine. During the dry season there is very little running water in the branch on which this dam was built.

The facts made by the complainant are that, for a long time previous to the grievance complained of, he occupied and resided with his family, including intestate, who was his son, upon a piece of land near Greeley and that after plaintiff's residence and occupation upon said land had commenced, the agents and employees of defendant acting for it . . . . dammed up certain water and thereby created a lake of water . . . . near his residence, being so close thereto as to affect his health and the health of his said family, and the enjoyment of his residence. It is then alleged that defendant was engaged in the development of iron and other minerals, and had caused said lake or pond to remain there for a long time and had placed or caused to be placed in said pond various substances, which are named, and thereby caused or allowed said water or lake to give off and out foul and unwholesome

and noxious air and caused said premises on which plaintiff resided to become unhealthy, causing plaintiff's boy to become sick so that he died; and plaintiff alleges that said sickness was proximately caused by the wrongful act or omission or negligence of defendant as aforesaid in building, maintaining or constructing said pond. . . . . The demurrers were that the cause of action did not survive to the personal representative and that the damages claimed did not survive. That there was nothing to show that plaintiff intestate was the owner of the land or had any possessory or leasehold interests therein; that the damages claimed were purely consequential and that no right of action was shown.

The Court held: The effect of the complaint is to aver that the death of the plaintiff's intestate, on account of which he sues, was caused by an issue of foul, unwholesome and noxious air from a pond which defendant corporation constructed in the neighborhood of his residence, where intestate, his minor child, lived with him. . . . . We are not required to know how plaintiff will prove the causation alleged; but accepting the allegation as true and provable on demurrer, there will be no question but that it shows damage peculiar to intestate, not merely in degree but in kind. . . . . It is obvious that to maintain an action for injury affecting the value of the freehold the plaintiff must have a legal estate. But if noxious vapors and the like cause sickness and death to one who has a lawful habitation in the neighborhood, no sufficient reason is to be found in the accepted definition of nuisance nor in the policy of the courts which would discourage vexatious litigation, nor in the inherent justice of the situation, as we see it, why the person injured, or his personal representative in case of death, should not have reparation in damages for any special injury he may have suffered, although he has no legal estate in the soil. Certainly a child has the right to live under his father's roof—is a lawful occupant of his father's home and in our opinion he should be accorded the same measure of protection against the construction of nuisances in the neighborhood which are so noxious and long continued as to materially affect his physical well being. . . . .

In the building of dams and the impounding of water for manufacturing purposes in this state, except in saw mill projects, it has not been considered worth while to even remove saw timber within the submergence areas. Experience has shown that in a year or two after submergence or partial submergence the timber dies; the limbs and tops first fall and with the seasonal floods are carried away. Within a few years the trunks fall and disappear in the same manner. Thus by these natural processes the areas of these impounded waters are cleared, and the banks below the normal water level are made free from vegetation. These conditions may be observed in all parts of the state.

About six miles west of Troy, on the south side of the Atlantic Coast Line Railway, there was built about five years ago a fish pond, by impounding the waters of Mill Creek. At the dam the pond is

approximately a quarter of a mile in width, and the pool extends upstream for a distance of about one mile. The timber, of which there was a considerable amount of second-growth pine, was allowed to stand. All the partially submerged timber except a little bay and magnolia died during the first summer after submergence, and most of the timber has fallen. The pond is not an attractive place from an aesthetic viewpoint, but for fish it is excellent. There are some places around the fringes of this pond where the water backs over flat surfaces producing conditions favorable for the breeding of mosquitoes, but the relative area of these overflowed places is very small compared with the large areas of swamp land permanently submerged by the pond. This pond has resulted in the creation of a combined pleasure and health resort out of what was formerly a malarial swamp. In the building of this pond, as in all other projects for utilizing the waters of the state, the question of effect upon public health was not raised until the suits against the Republic Iron and Steel Company were filed, of which mention has already been made.

In 1910 the state of Alabama began the construction of a dam across the valley of Mortar Creek, at Speigner, Alabama, at which place is located the state cotton mill operated with convict labor. The state owns about 3500 acres at Speigner, and the Mortar Creek bottoms include about a thousand acres of the state property. These lands were covered with a dense growth of timber, little of which was suitable for manufacturing purposes, and the lands even if cleared would not have been suitable for cultivation, being for the most part swamp and overflow lands. This tract being located practically in the center of the state's property was a menace to the health of the community. It was a veritable mosquito heaven.

A dam nearly a mile in length across the valley has been completed and a lake of 800 acres in area created. All the standing timber within the submerged area has been removed. The power created by this development is now being utilized to operate the electric light system, water works plant, grist mill and for part of the year to operate the cotton mill. The work was all done with convict labor. The permanent submergence of those 800 acres of swamp land has added greatly to improved public health conditions in that vicinity.

In order to be able to carry the water level of the Speigner dam to the desired height, it was necessary for the state to acquire about 75 acres of privately owned lands. Being unable to negotiate for

these lands, condemnation proceedings followed. The state contested the price fixed by the commission for the condemned land, on the assumption that the land appropriated was waste and uncultivatable property, and that the remaining portion of contiguous lands would be increased in value by reason of the state's constructions, being made more healthful and habitable. In this view, the state health officer concurred, and was a witness for the state.

In the canalization of the Tombigbee and Warrior Rivers the United States government has built in all 17 locks and dams. Lock No. 1 is located on the Tombigbee 111 miles above Mobile, and Lock No. 17 is located on the Black Warrior 388 miles above Mobile. The backwater above Lock 17 extends up the Locust Fork of the Warrior to a point 425 miles above Mobile, and on the Mulberry Fork to a point 444 miles above Mobile, the confluence of these forks being 408 miles above Mobile. In addition to the pool extending 53 miles up these two main forks of the river, the backwater above Lock No. 17 extends up small tributary streams for a total distance of about 20 miles. The total distance, or length of the pool above Lock No. 17 created by the 63-foot dam, is 93 miles. Outside of the natural banks of the river and its tributaries, about 3500 acres of land has been submerged. In the construction of this lock and dam no effort has been made by the government to cut the timber that has been submerged.

In all the improvement work on the Tombigbee and Warrior Rivers, the only timber removed was that which might obstruct navigation. This is the same policy that has been followed in the construction of the Panama Canal.

So far as records are available, and from the testimony of many physicians whom the writer has interviewed, the year 1900 was the most unhealthful along the Warrior River from Tuscaloosa to Demopolis. In the late summer of that year malaria was epidemic not only along the Warrior and Tombigbee bottoms, but extended far back into the neighboring country and higher lands. Malaria prevailed in fact in all parts of the state.

At that time there were no completed locks. The dams were in course of construction, but the waters in both rivers had an unobstructed flow. During the summer there were two exceptionally high stages of the rivers, causing streams everywhere in the state to overflow their banks, and to spread over vast tracts of land in the Coastal Plain. The heavy rainfall of that season undoubtedly cre-

ated numerous favorable breeding places for mosquitoes, which ordinarily do not exist.

Assuming that the unprecedented rainfall of the summer of 1900 explains the unusual amount of sickness in the autumn of that year, yet the fact remains that since these two rivers have been completely canalized, there has been less and less malaria each succeeding year, and the health conditions along both rivers have steadily improved.

The impounded waters in the Birmingham district include a reservoir on the Five Mile Creek and a reservoir on the Little Cahaba River which are used as sources of supply by the Birmingham Water Company and are estimated to have during drought a combined capacity of 42,500,000 gallons per day. An excellent system of treatment and filtration is employed before these waters are served to the public.

In addition to the above reservoirs, the Tennessee Coal, Iron and Railroad Company built for manufacturing uses an impounding reservoir on Village Creek near Ensley, capable of furnishing daily 50,000,000 gallons in dry seasons. Artificial lakes have also been built at East Lake and West Lake near Birmingham. The sites of all these impounding basins were cleared of standing timber to the water line before submergence.

Tuscaloosa is the only city outside of Birmingham in Alabama drawing its public water supply from a large impounding basin, the supply being obtained from the pool caused by Lock No. 12 Warrior River.

When the Spring Hill pumping station of the Mobile water works was built in 1900, a dam across Three Mile Creek was constructed, which created a shallow pond submerging several acres of dense vegetation. Superintendent M. F. Sullivan in his report, dated Mobile, March 15, 1915, says:

> In my report to the mayor and general council on May 15 I recommended that the dam across Three Mile Creek at the pumping station be opened up and a new spillway be constructed, the crest of which would be on the same elevation as the normal water surface of the creek, thereby eliminating the pond feature of our water supply, as same had not been cleared of all vegetation, top soil, etc., and the capacity of the creek being sufficient to supply the future demands for several years, no storage of water was necessary. But before anything was done in the matter the unprecedented rainfall of June 26 (12.67 inches in 24 consecutive hours) caused an enormous rise in the creek, and the 50-foot spillway provided for the escape of only a small portion of the storm water, and as a result the water soon washed out about 150 feet of the dam and also the old spillway.

The above enumeration covers the list of impounded waters in Alabama. It will be seen that only two cities derive their public water supply from impounding basins and these supplies are mechanically treated before being used.

The relationship of impounded waters in Alabama to public health is therefore limited to the influences they may have other than through water borne diseases such as typhoid, para-typhoid or paracolon fevers, cholera, etc., and may be studied in their relationship with reference to

1. Humidity and changes in hygrometric conditions.
2. As a source of foul or deleterious odors.
3. As breeding places of mosquitoes.

The complex relations of humidity and evaporation make it practically impossible to compute, with any degree of accuracy, evaporation over an extended surface of a water shed or drainage area—or to ascertain the effect on humidity in the various river basins, due to the comparatively minor changes in the surface conditions caused by clearing of timber lands or adding to the exposed water surfaces by the construction of impounding basins. The average annual relative humidity from Mobile to the gulf is over 80 per cent and for the rest of the state from 70 to 80 per cent. A given air space at a given temperature can contain only a definite amount of water. If it contains less it will endeavor to fill up by evaporation; if it contains more the surplus moisture will condense. The higher the temperature the more moisture it takes to saturate the air.

The experiments of Desmond Fitzgerald on evaporation from water surfaces (see *Trans. Am. Soc. C. E.*, vol. xv, p. 581) show that evaporation depends upon three elements: The vapor pressure corresponding to the temperature of the surface of the water; the vapor pressure corresponding to the dew point of the atmosphere, and the velocity of the wind.

For the five months, June to October inclusive, the probable average daily evaporation from exposed water surfaces in Alabama is about 0.16 inch and the average rainfall throughout the state approximately equals in depth the amount of evaporation from the water surfaces for the year.

Since the absolute humidity decreases rapidly from equator to the poles but decreases more rapidly in the interior of the continents than over the oceans, it is evident that even the relative humidity in any section of the state which is highest at night and lowest in

the hottest part of the day, can be but slightly influenced by changes in the areas of natural water surfaces since these areas are insignificant compared with the ocean surfaces from which the atmosphere draws its chief supply of moisture. Furthermore the areas of the water surfaces of the impounded streams in many of the canalization projects have been but very slightly increased because of the steep natural slopes of the banks. The total areas of these impounded water surfaces compared with the land areas are exceedingly small. It is therefore evident that the impounded waters have little or no effect upon the normal humidity or atmospheric conditions in their vicinity.

2. (a) As a source of foul or deleterious odors, impounding reservoirs will be considered into which vegetable, animal or mineral matter is transported as in the Village Creek reservoir of the Tennessee Coal, Iron and Railroad Company already referred to and a more complete description of which will be found in the article on "Water and Air Movements," by Mr. W. F. Wilcox (PROCEEDINGS OF AMERICAN WATER WORKS ASSOCIATION, 1913, p. 310). When this reservoir was originally planned, fears were entertained that at some

> future time it might become so filled with putrescible matter as to be objectionable, causing sickness to the adjacent population. It was therefore determined to take all possible precautions during construction, and to keep daily observations of all physical conditions and to make periodical examinations.

A pipe line 8 miles long was constructed to remove waste from a by-product plant; a sewage disposal plant was put into service to treat sewage reaching the reservoir and at coal mines and washers settling arrangements were constructed; from the reservoir basin vegetable matter was removed before the water was impounded. These precautionary measures were undertaken because this impounding reservoir is strictly a conservation proposition and during periods of drouth there will be a considerable draw-down on the basin and no overflow. The waste from the by-product plants and mines carried around this reservoir, empty into Village Creek below the dam and are emptied through this creek into Locust Fork in the pool created by the dam at Lock No. 17 Warrior River. This last mentioned impounding reservoir is the largest in the state and receives into its waters the manufacturing wastes of the Birmingham

district, the mine wastes of the Warrior coal fields, the vegetable and animal wastes of a drainage area of approximately 4000 square miles and the human wastes of a population of about 200,000. Notwithstanding all these polluting influences the pool caused by Lock and Dam No. 16 immediately below this pool has never emitted foul odors except during the first fall season after its completion; the odors at that time being due to the decomposed land flora which had been submerged in the reservoir itself.

It is likely that the same odors from decomposing vegetation will be noticed this fall around the margins of the reservoir caused by Lock and Dam No. 17.

So far as records are available, the impounding reservoirs in this state, into which animal, vegetable or mineral matter is transported, have not been the source of foul or deleterious odors, except when the waters were first impounded.

(b) Whipple says (*"Microscopy of Drinking Water,"* p. 186): "Almost all surface waters have some odor. Many times it is too faint to be noticed by the ordinary consumer, though it can be detected by one whose sense of smell is carefully trained." This statement is undoubtedly true with reference to the impounded waters of Alabama during the late autumn, when decaying vegetation of the catchment and on the littoral is carried into the reservoirs. These odors may be unpleasant occasionally, but in the basins herein considered by reason of the dilution due to the large bodies of water, the almost constant forward or downstream movement of the waters, and the frequent rains causing freshets, the odors can not be said to be especially disagreable or offensive. It is not conceivable that these odors could in any way be detrimental to public health.

3. As breeding places for mosquitoes.

MALARIAL FEVERS

Prevalence and Geographic Distribution in Alabama

The first available statistics which were studied were of the admissions of cases into the United States Marine Hospital at Mobile during the 10 years 1902 to 1911, inclusive. (See Public Health Reports, vol. XXVII, No. 52, Dec. 27, 1912, by Surgeon R. H. von Ezdorf.) Available statistics at the office of the Alabama State Board of Health begin with the year 1910, but are quite imperfect for the years 1910–1913 inclusive. This incompleteness of records is due to the failure of the physicians of the state to make the reports. In his 1912 report Surgeon von Ezdorf arrives at the following conclusions:

1. All forms of malarial fevers prevail in the state of Alabama.

2. Morbidity reports indicate that in September, 1912, about 1 person for every 50 population suffered an attack of malarial fever, and during October 1 person in 67 had an attack.

3. The types of infection, in order of preference, are: Tertian, esto-autumnal and Quartan.

4. The chronic type of malarial infection is proportionally greater in the colored race than in the white.

In every county in the state the reports state that there are swamps or poorly drained lands. Mosquitoes were reported as present in all counties for which information was given on the subject.

The same authority (see *Public Health Reports*, vol. 29, No. 18, May 1, 1914,) states that

The regions in the state in which malaria prevails to the greatest extent are apparently in the Tennessee Valley belt, which extends across the northern part of the state, and also in the central prairie region known as the "Black Belt."

The morbidity reports indicate that the disease exists in every county in the state, the tertian type being most prevalent.

The reported deaths from malarial fevers total 434 for the year 1913, which is equal to 2 per cent of the reported deaths from all causes, and is at the rate of 20.3 per 100,000 population.

The United States Public Health Service is now engaged in an investigation of the prevalence and geographic distribution of malarial fevers in the states of Alabama, Arkansas, Mississippi, South Carolina, Georgia, Florida, North Carolina and Tennessee. For the year 1913 cases were reported from every county in the states of Arkansas, Alabama, Mississippi; all counties in South Carolina and Florida, except one in each state, from which no reports were received, and in 138 counties of the 148 in Georgia. August and September are the months of greatest prevalence in all these states.

MALARIAL SURVEYS

The United States Public Health Service made malarial surveys in selected localities during 1913 in the states of Arkansas, Alabama and North Carolina, in which the topographic and climatic conditions of the locality, and social, hygienic and economic conditions of the communities and industries were studied. (See Reprints Nos. 156, 160, 172 and 193 from Public Health Reports.)

Dr. H. R. Carter, Senior Surgeon, United States Public Health Service, in charge of the surveys in North Carolina, read a paper on

"The Effect of Impounded Water on the Incidence of Malaria" before the meeting of the Southern Medical Society at Richmond, Virginia, November 9, 1914, in the introduction of which he says:

> Last fall a new problem was presented to me—the effect of large bodies of impounded water on the production of malaria. It was interesting; it was important and it was new. . . . . Of its importance there can be no question, as it is especially concerned with the large ponds of the power plants of the South; to which plants this country is looking for no little part of its future development. I was looking over a map of the Southern Electric Co. and a reasonable estimate of the cost of the plants there given as in operation would exceed $150,000,000 and as many projected. . . . . If these plants, or rather the ponds of these plants, are a serious menace to the health of the community, either they must not be allowed, or can only be allowed by rendering unhealthful, or even uninhabitable, a considerable area adjacent to them. In either case the loss involved is a very serious one, and the problem is certainly new.

Dr. Carter's paper read at Richmond and his report to the government published in *Public Health Reports*, vol. 29, No. 52, December 25, 1914, on "Impounded Waters," were the pioneer papers on the subject, contributing largely to our present knowledge of the effect of large bodies of water confined by artificial structures on public health, and indicating the character of surveys and investigations which should be made to obtain a broader knowledge of the subject.

A study of the impounded waters on the Coosa River in Shelby, Chilton, Talladega and Coosa Counties, Alabama, was made by Mr. J. A. Le Prince, sanitary engineer, United States Public Health Service, during the months of October and November, 1914 (see Reprint No. 257 from *Public Health Reports*), also of the same reservoir by Mr. J. V. Donley, Sanitary Engineer of the Board of Health of Alabama at the same time the investigations were being made by Mr. Le Prince. (See "Impounded Waters," by J. V. Donley, *Board of Health of Alabama Report.*)

During the period of the above investigations (October and November, 1914,) the writer spent about two weeks with local physicians in the same counties, making a special investigation of the sanitary conditions not only in the neighborhood of those homes near the reservoir but in many cases distant several miles from the pool.

The investigations which were inaugurated in the fall of 1914 will be continued during the present year by the United States Public

Health Service and doubtless by the State Board of Health of Alabama, with the object of determining (1) the influence of such waters on the incidence of malaria; (2) what conditions affect this influence for good or for ill; and (3) what measures can be taken to minimize the ill effect of such waters and to increase to a maximum their good effect.

The investigations during the fall of 1914 and those which are now proposed by the United States Public Health Service on the Coosa River basin, were doubtless inspired by the numerous suits (700) filed in the four county and circuit courts in which the reservoir is situated, for alleged damages due to the creation of this lake above Lock and Dam No. 12.

Since the dam was built in strict conformity to plans approved by the war department, the pool created by it becomes part of the national government's project for the improvement of navigation on that river, the power company incidentally utilizing the power created by the dam, has no authority in any way to change the level of the lake determined by the crest of the dam now built, except in so far as it may be permitted to draw down the lake level to a point that will not interfere with navigation or the operation of the locks when installed.

Mosquitoes

It has been proven beyond a doubt that:

1. Mosquitoes carry malaria from man to man.
2. That the disease can be contracted in no other way than by being bitten by malaria-carrying mosquitoes.

Just how many kinds of mosquitoes there are in the world today nobody knows. Distributed as they are, there are large areas in which the mosquito fauna is not known, and will not be for years to come. One of the greatest authorities (F. V. Theobald) states that the number of species will not be less than 1000. At present the known species are grouped in about 50 genera. Male mosquitoes, with probably rare exceptions, do not bite—only the females do.

The most common mosquito in Alabama is the Culex impiger, or common house mosquito, which has been reported from Alaska and is found in all the Southern States.

The Stegomyia calopus, or yellow fever carrier, is universally distributed over Florida and probably Alabama, having been identified

in 14 counties in 1913 from specimens received at the Marine Hospital at Mobile.

Everybody knows that the mosquitoes of the genus Anopheles are responsible for the transmission of malaria. The Anopheles punctipennis, the most common species in Alabama, is not however a carrier, or has not to the present time been shown to be a carrier. The A. quadrimaculatus and A. crucians are probably the chief carriers in Alabama.

Breeding Places of Anopheles

All mosquitoes breed in water and in Alabama probably at all times during the year, the intensity of development corresponding to temperature conditions, the greatest activity following the high temperatures of the late summer and fall. A study of the topography of Alabama shows there are breeding places in all parts of the state which may be designated as those of a "constant" and those of a "temporary" character. Those of a constant character are places found along poorly drained creeks, cane and cypress brakes, marshy places in woods and along river banks, ditches containing water at all seasons with grassy banks. The marshy places about springs and along small branches and creeks with wooded and grassy banks probably furnish the most favorable conditions for breeding even during the winter months. In such places larvae of the Culex and Anopheles were found in November and in February of the present year. On April 11 larvae of Culex were procured in great numbers in a spring fed grassy pool in a ravine near Lock No. 10 Warrior River, some of which hatched on April 18. Larvae from another pool near by obtained by the writer on April 14, hatched on the 19th of April.

It is evident that in these protected pools eggs or larvae have been present during the winter as well as mosquitoes in the immediate vicinity. The protection of the wooded grounds, evergreens and warmth of the spring waters, make such places ideal winter resorts and permanent abodes for the mosquito. The pools above mentioned are certainly complete breeding places, i.e., places developing imagos from eggs deposited at that place.

Temporary breeding places are found in poorly drained ditches, gutters, barrels, tin cans, bottles, hoof-prints of stock, pools in roads, or in water courses that dry out in a short time unless refilled. Such places may become for the time being a complete breeding place.

A place may be designated as incomplete when, although eggs are deposited there, yet imagos are not there developed from them, as in a creek or river completely scoured out by a freshet, all larvae being removed and either drowned or carried elsewhere. Such a creek may supplement an incomplete breeding place as a bayou or the backwater at creek's mouth transporting larvae that find shelter in the floatage sometimes found in such places.

In the investigations by the writer in Shelby, Chilton, Coosa and Talladega Counties, Alabama, in October and November, 1914, Anopheles larvae were obtained at or in the vicinity of practically all of the homes inspected and it was only necessary to locate standing, quiescent water to find them. Specimens were obtained from many wells from which water was drawn by buckets attached to ropes, from springs in the hollow and on the hillside, in the marshes and quiet waters along the banks of rivulets and small streams, pools in roadways. In fact wherever quiet water could be found, except in occasional places that had been heavily oiled, specimens were obtained.

The shores of the Coosa River were carefully examined in many places. Only at springy places along the shores and above the lake level and at the mouths of creeks in the dead water or at the head of backwater in bayous were we able to procure larvae, few of which were Anopheles. At no place were we able to procure or to see larvae in large numbers.

The writer was strongly impressed from observations made at that time and since, that the large streams with their impounding basins are not the important breeding places of mosquitoes in this state. It is true that eggs and larvae are transported into these streams and a percentage, probably small, mature and survive. Some favorable places for breeding will be found such as have hereinbefore been indicated; but these areas are relatively small compared with the natural and complete breeding places that have been permanently submerged. The writer believes when the facts are better known and the problem is more fully worked out, malaria control will become largely one of local sanitation and drainage. Malaria will then be largely prevented or eradicated by measures applied at or near the home.

Natural Enemies

The deep waters, wave action and currents of the impounding reservoirs described make such waters unfavorable places for the

breeding of mosquitoes. In the larval and wiggler stage, they have many enemies; minnows eat them, the larvae of dragon flies, beetles or mellow-bugs eat them, "disease attacks them, fungi get on them and kill them;" they die for lack of food, they devour each other, they get entangled or under leaves and drown, the water dries up and in this way millions perish before they are grown. Many perish while emerging from the pupa by reason of the capsizing of the cast-off skin serving as a boat.

Those that do hatch successfully meet new enemies among dragon-flies, bats, lizards, toads, frogs, night hawks and a host of other enemies.

SURVEYS NECESSARY

United States Government Surveys

The purpose of the United States Public Health Service Surveys now in progress has been already described.

In connection with the construction of Dam and Lock No. 17 on the Warrior River field work and surveys had been carried out prior to the completion of that work as follows:

Bench-Mark levels from "mean-tide" Mobile Bay were established and extended from Lock No. 16 up the river beyond and above the backwater on both Mulberry and Locust Forks.

Complete topographical maps with 5-foot contour intervals were made from surveys covering the entire basin of submergence.

The surveys are usually made to the tops of river banks, but in some cases have only been extended for one contour above pool level.

Careful and detailed topographic and geological surveys of the sites for locks, dam and appurtenances which receive the careful study and investigation which their importance demands.

In making the traverse of the banks and bed of the Warrior and its tributaries, all lands liable to submergence were carefully mapped, tied in with section corners, and in many cases were photographed. Some cultivated lands have been submerged. Property of this kind received the most careful attention on the part of the government engineers, photographs being made of all structures, and of various divisions of the land, three photographs from different viewpoints being taken of each structure or piece of land.

Outside of the sites for dams and locks, the government purchases little land until after the completion of the work of actual submer-

gence of the same. Along the navigable streams the ownership of the banks is often a mooted question, because of the difficulty of establishing high, low and normal flow lines.

While it is the policy of the government to be fair and even liberal in its acquirement of such lands, frequently the small and ignorant property owner becomes the victim of unscrupulous lawyers and land grabbers. These rascals go to such owners and tell them that the government intends to submerge a large part of their land; that they can not sue the government, and that the balance of their land will be uninhabitable after the dam is completed on account of malaria, etc. By such misrepresentations lands have been recently sold around the pool created by the dam at Lock No. 17. These lands are all underlaid with coal, and in most cases the mineral value per acre far exceeds the surface value.

In view of the vast interests involved in connection with the construction of these impounding reservoirs, including the questions of public health, regulation of stream flow and navigation, utilization and conservation of natural resources, security for investors and all other economic questions, the importance of systematic physical and zoölogical surveys of the site and neighborhood of any proposed impounding basin must be apparent.

Such surveys have not been made in the past or in connection with any known basin so far as the writer is informed. Had such investigations been made before the building of a number of large dams in this state and in the Carolinas the litigation pending would have been avoided.

Dr. Carter says:

> Since we wish to determine the whole effect of the pond on the production of malaria, we must compare the condition which existed before the pond was made with that which exists afterwards. If the malaria which the pond produces be counted a debit, the malaria it prevents must be counted a credit. It is the *change* in conditions we would know.

The physical survey should include all the field work required for the production of a complete record of the topographical, geological and botanical characteristics of the site intended to be submerged as well as the surrounding neighborhood.

The maps of these surveys should be made under the direction of an expert cartographer familiar with the methods of map construction and the conventional signs commonly employed. He should

be possessed of such actual knowledge of map making as is only gained by practical experience in field surveying of this class. He should be able to distinguish between the quality and value of the various symbols. These maps should clearly show the location of all pools, marginal wet lands or actual breeding places and the areas of such places together with the location of all temporary or permanent breeding places on tributary streams or neighboring lands.

The physical survey of the site should include careful investigations to determine whether the places examined are such as would make them favorable breeding places for Anopheles, and if so, are they so situated as to produce malaria; to determine what places are actually breeding malaria-vectors; to make a careful survey of all residences close enough to be influenced by any proposed constructions; the distances from such residences and any obstacles between the place examined and such residences; character of the water, vegetation, protection against wave action, floatage, proximity of blood supply, etc.

The Zoölogical Survey will take account of whether Anopheles or other mosquitoes are found breeding in any place and to what extent; the species of Anopheles, whether or not a malaria-vector; the presence of fish and other aquatic enemies; a careful study of and classification of Anopheles or other mosquitoes found about the premises of adjacent residences to proposed site and in the neighboring tributary streams or breeding places.

The sanitary survey should include a careful investigation of all health records of all people living in the community or within reasonable range of the proposed reservoir including blood examinations and a complete malarial index of the neighborhood or community. In this connection it is believed there will be little trouble experienced in securing the active coöperation of the board of health since the importance of these investigations is now so well understood.

DISCUSSION

MR. W. F. WILCOX: The speaker does not think discussion on the subject of "Impounded Waters" would be of any value to you unless you had at hand your data so as to show what the result was. We have a lake 7 miles long, varying in depth from zero to 80 feet. We keep close watch of this reservoir, having a chemist in charge who makes chemical analyses of the water, both mineral and bac-

teriological. We keep a record of the temperature of the water, taking this temperature at least once a week, also the humidity and the velocity of the wind.

One of the difficulties that we have to contend with is that at the head of the lake about 6,000,000 gallons of sewage empties. That sewage has been filtered before it is turned into the reservoir. The amount of purification that will take place in an impounding reservoir in such a case is remarkable. Our analyses show that as the water deepens and is allowed to run the purification is quite beyond our expectations. A discussion of impounded reservoir waters is not of any value unless you have detailed data. The speaker has such data for five years, and if any of you want any information at any time, he will be very glad to answer your questions; but offhand discussion without detailed data he does not think is of any value.

The speaker wishes to say that this reservoir that he has charge of is not for drinking water, it is for mechanical purposes; but we have been able to purify the water to such a degree that it meets the chemical and bacteriological standards. If it were not for the history of the water, we could easily palm it off as a very sanitary drinking water.